Independent Verification and Validation (IV&V)

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Agenda

- Challenges
- Solutions
- IV&V Defined
  - » Verification
  - » Validation
  - » Independence
  - » IEEE IV&V - CMMI® V&V
- IV&V Relationships to other Disciplines (Test, Quality Assurance)
- Overview of Independent Verification & Validation (IV&V)
- Tailoring IV&V
- Questions/Comments
- References

Challenges to System Developing

- When developing, delivering, and acquiring systems and system products developers and acquirers face many challenges.
- Challenges can exist with many items and activities:
  - Cost
  - Schedule
  - Technical
  - Management
  - Programmatic
  - Process
  - Quality
  - Others?

Challenges

- Consequences may be numerous if challenges not mitigated
  - Cost overruns
  - Late deliveries
  - Technically inadequate
  - Mismanagement
  - Programmatic difficulties
  - Lack of sound process
  - Irate customer
  - Canceled project
  - Others?

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- *Solutions*
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Solutions

- There are many solutions for an organization to mitigate these challenges
  - Proper project planning
  - Adequate budgets
  - Adequate schedules
  - Proper requirements development and management
  - Proper project management
  - Program monitoring and control
  - Contract tracking and oversight
  - Product evaluation
  - Performance management
  - Risk management
  - Quality assurance
  - Configuration Managment
  - *Independent Verification and Validation (IV&V)*
  - Others?

Solutions

- This presentation will focus on IV&V
  - » IV&V alone will not guarantee mitigation of all challenges
  - » But, can go a long way in solving many

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IV&V Defined

- Independent Verification and Validation (IV&V) is often misunderstood and misapplied
- In many cases a distinction is not made between verification and validation; V&V is treated as one activity
  - » Often is heard: “We are doing IV&V on a document”
  - » What was typically being conducted was an independent review of a document
- IV&V is an activity across the life cycle
  - » Not an isolated effort performed at random intervals
  - » Nor performed as necessary once on one or few components or items of interest

IV&V Defined

- From IEEE Standard 1012 2004, IEEE Standard for Software Verification and Validation; IEEE Computer Society
  - » Verification: (A) The process of evaluating a system or component to determine whether the products of a given development phase satisfy the conditions imposed at the start of that phase. (B) The process of providing objective evidence that the software and its associated products conform to requirements (e.g., for correctness, completeness, consistency, accuracy) for all life cycle activities during each life cycle process (acquisition, supply, development, operation, and maintenance); satisfy standards, practices, and conventions during life cycle processes; and successfully complete each life cycle activity and satisfy all the criteria for initiating succeeding life cycle activities.
    - Answers the question: are we building the products right ?

NOTE: Although not specifically mentioned this author interprets this at also investigating the processes that are used to develop and manage the components and products.

IV&V Defined

- Validation: (A) The process of evaluating a system or component during or at the end of the development process to determine whether it satisfies specified requirements. (B) The process of providing evidence that the software and its associated products satisfy system requirements allocated to software at the end of each life cycle activity, solve the right problem (e.g., correctly model physical laws, implement business rules, use the proper system assumptions), and satisfy intended use and user needs.
  - Answers the question: are we building the right products?

NOTE: Although not specifically mentioned this author interprets this at also investigating the processes that are used to develop and manage the components and products.

IV&V Defined

- Independent Verification and Validation
  - Performed by an organization that is:
    - Technically
    - Managerially
    - Financially

    Independent of the development organization
  - Supports objectivity

V&V Defined

Extracted from CMMI® - for Development, Version1.3

- Verification
  - » The purpose of Verification (VER) is to ensure that selected work products meet their specified requirements. In other words, verification ensures that "you built it right."
- Validation
  - » The purpose of Validation (VAL) is to demonstrate that a product or product component fulfills its intended use when placed in its intended environment. In other words, validation ensures that "you built the right thing."

NOTES:

- The IEEE and the CMMI® definitions are somewhat different but accomplish the same results

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IV&V Relationships to Other Disciplines

- Although IV&V conducts some or similar activities as:
  - The Test Organization, and
  - The Quality Assurance Organization
- IV&V conducts them with a different filter

IV&V vs. Test

- Several types of tests can occur for product acquisition and product development
  - Component or Unit tests
  - Commercial-off-the-shelf (COTS) tests
  - Formal Tests
    - Functional Tests
    - Integration Tests
    - System Acceptance Tests
    - Operational Tests
    - Certification Tests

IV&V vs. Test

- Implementers conduct their own tests at the unit and component level to ensure that the units and components meet their documented and approved design
  - » Indirectly ensures that allocated requirements have been met
  - » Requirements' allocation should be reflected in the design
- Development test team, separate from the implementation team, conduct tests at the formal level to ensure that requirements have been met and that interfaces are correct and that products are ready for production
  - » Also called Validation

IV&V vs. Test

- IV&V, independent of the development and test teams, objectively evaluate that:
  - Units and Components meet their documented design
  - Products meet requirements
  - Interfaces are correct
  - Products are ready for production
  - Again, IV&V is performed with a different filter completely separate and independent of the organization developing the system

IV&V vs. Quality Assurance

- Quality Assurance (QA) objectively assures:
  - Technical and programmatic products are developed according to standards, plans, procedures that govern their formats and contents
    - QA typically does not evaluate the technical adequacy of products
  - Technical and programmatic processes are executed according to standards, plans, procedures and process descriptions
  - QA provides objectivity by reporting to management above the project and/or program level

IV&V vs. Quality Assurance

- IV&V objectively evaluates
  - Technical and programmatic products are developed according to standards, plans, procedures and technical requirements that govern their formats, contents and functionality
    - IV&V evaluate the technical adequacy of products
  - Technical and programmatic processes are executed according to standards, plans, procedures and process descriptions
  - IV&V provides objectivity by reporting independently to an organization that is separate from the development organization

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Planning Phase

- During the planning phase IV&V activities are planned
  - Identify key IV&V stakeholders
  - Identify IV&V lifecycle activities
    - Balance with other project activities
  - Identify and acquire IV&V resources
  - Identify and acquire IV&V budget
  - Tailor IV&V to the scope of the project
    - More on this later
  - Identify and select IV&V staff
  - Develop IV&V Plan
  - Review and approve IV&V Plan

Independent Verification

- Independent Verification is conducted throughout all life cycle phases: requirements, design, implementation, integration, test, and production
- Activities of verification may include:
  - Reviews and audits
    - Product reviews
    - Peer reviews
    - Process audits
  - Analysis
  - Prototypes
  - Simulations

Planning Phase

- During the planning phase some Independent Verification is conducted against Program Planning
  - » Development Schedules
  - » Project Management Plans
  - » Quality Assurance Plans
  - » Configuration Management Plans
  - » Risk Management Plans
  - » Software Development Plans
  - » System Engineering Plans
  - » Hardware Development/Acquisition Plans
  - » COTS Plans

Independent Verification

Requirements Phase

- The process of evaluating a system or its components to determine whether the products of the requirements phase satisfy the conditions imposed at the start of that phase with a main focus on requirements.
- Products and their related activities may include:
  - » Requirements Specifications
  - » Interface Specifications
  - » Test Plans
  - » Updated Plans and schedules fromthe Planning Phase

Design Phase

- The process of evaluating a system or its components to determine whether the products of the design phase satisfy the conditions imposed at the start of that phase with the main focus on design.
- Products and their related activities may include:
  - » Design Documents
  - » Interface Design
  - » Updated
    - > Requirements Specifications
    - > Interface Specifications
    - > Development Schedules
    - > Test Plans
    - > Plans from the Planning Phase

Implementation Phase

- The process of evaluating a system or its components to determine whether the products of the implementation phase satisfy the conditions imposed at the start of that phase with the main focus on implementation.
- Products and their related activities may include:
  - » Code / HW development / COTS procurement
  - » Unit Test Plans
  - » Unit Test Procedures
  - » Unit Test Reports
  - » Updated
    - > Design Documents
    - > Interface Design
    - > Requirements Specifications
    - > Interface Specifications
    - > Development Schedules
    - > Test Plans
    - > Plans from the Planning Phase

Independent Verification

Integration Phase

- The process of evaluating a system or its components to determine whether the products of the implementation phase satisfy the conditions imposed at the start of that phase with the main focus on integration.
- Products and their related activities may include:
  - » Integration Plans
  - » Integration Procedures
  - » Integration Witness
  - » Integration Reports
  - » Updated
    - > Hardware Components
    - > Code
    - > Unit Test Plans
    - > Unit Test Procedures
    - > Unit Test Reports
    - > Design Documents
    - > Interface Design
    - > Interface Design
    - > Requirements Specifications
    - > Interface Specifications
    - > Development Schedules
    - > Test Plans
    - > Plans from the Planning Phase

Formal Test Phases

- The process of evaluating a system or its components to determine whether the products of the test phases satisfy the conditions imposed at the start of those phases with the main focus on test.
- Formal test phases may include:
  - » Functional Tests
  - » System Integration Test
  - » Acceptance Test
  - » Operational Tests
  - » Certification Tests

Formal Test Phase

- Products and their related activities may include: :
  - » Test Plans
  - » Test Descriptions
  - » Test Procedures
  - » Test Witness
  - » Test Reports
  - » Updated
    - > Integration Plans
    - > Integration Procedures
    - > Integration Reports
    - > Hardware Components
    - > Code
    - > Unit Test Plans
    - > Unit Test Procedures
    - > Unit Test Reports
    - > Design Documents
    - > Interface Design
    - > Requirements Specifications
    - > Interface Specifications
    - > Development Schedules
    - > Test Plans
    - > Plans from the Planning Phase

Independent Validation

- The process of evaluating a system or its components during, or at the end of the development process, to determine whether they satisfy their specified requirements.
- Planning for Independent Validation activities starts at the requirements phase and continues throughout other phases.
  - This includes validating that requirements are feasible, traceable and testable
- Products and their related activities may include:
  - Requirements' Specifications
  - Validation Plans
  - Validation Descriptions
  - Validation Procedures
  - Code
  - Validation Conduct
  - Validation Reports

Independent Validation may or may not include the actual execution of tests, more on this later *(Tailoring IV&V)*

Operational Phase

- The same activities that are executed, from a lifecycle phase perspective, may need to be conducted during operation
  - Correcting defects
  - Correcting requirements
  - Implementing changes
    - Enhancements
    - New functionality
    - Modernization
    - Legacy upgrades
    - Integration into system-of-systems
    - Etc.
- These may require repeating some or all development lifecycle phases or activities
  - May require the execution of IV&V as appropriate

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Tailoring IV&V

- The scope of the IV&V effort is dependent on several factors such as:
  - Cost
  - Size
  - Schedule
  - Technical Complexity
  - Criticality
  - Security
  - Safety
  - Risk
  - Team complexity
  - Organizational complexity
  - Requirements maturity
  - Level of integration
- IV&V can be very costly, in some cases costs can be as much as those of the development effort for complex and critical systems.
- IV&V factors need to be analyzed resulting in a cost effective IV&V effort that is appropriately tailored to the scope of the application.

Tailoring IV&V

- By conducting an analysis of the scope of the application in relation to: cost, size, schedule, complexity, criticality, security, safety, risk, team complexity, organizational complexity, requirements maturity, and level of integration an IV&V effort can be appropriately tailored to the scope of the application.
  - » Full scale IV&V would include all the activities described.
  - » Tailoring may include the conduct of all or some of the activities excluding the Independent Validation.
  - » It could involve only Independent Validation.
  - » Any variation of the 2 above.
  - » IV&V may be tailored by only including items that are:
    - > Time critical and/or
    - > Safety critical and/or
    - > Security critical

Tailoring IV&V

- Validation could include full scale independent testing
- Validation could include oversight of contractor testing
  - No independent testing
- Verification could include items that are:
  - Identified as high risk
  - Selected by Management
  - Randomly selected
  - A percent of all items such as 10%, 20%, 30%, etc.
  - Only deliverables
- IV&V could include only technical requirements
- IV&V could be independent oversight of some or all contractor's V&V activities

Risk Based IV&V

Integrity Levels

Description	Levels
♦ Software elements must execute correctly or grave consequences (loss of life, loss of system, economic or social loss) will occur. » No mitigation is possible – High level of IV&V	4
♦ Software element must execute correctly or the intended use (mission) of the system/software will not be realized, causing serious consequences (permanent injury, major system degradation, economic or social impact) » Partial to complete mitigation is possible – Medium level of IV&V	3
♦ Software element must execute correctly or an intended function will not be realized, causing minor consequences. » Complete mitigation possible – Moderate level of IV&V	2
♦ Software element must execute correctly or intended function will not be realized, causing negligible consequences. » Mitigation not required – IV&V not needed	1

IEEE Standard 1012 2004

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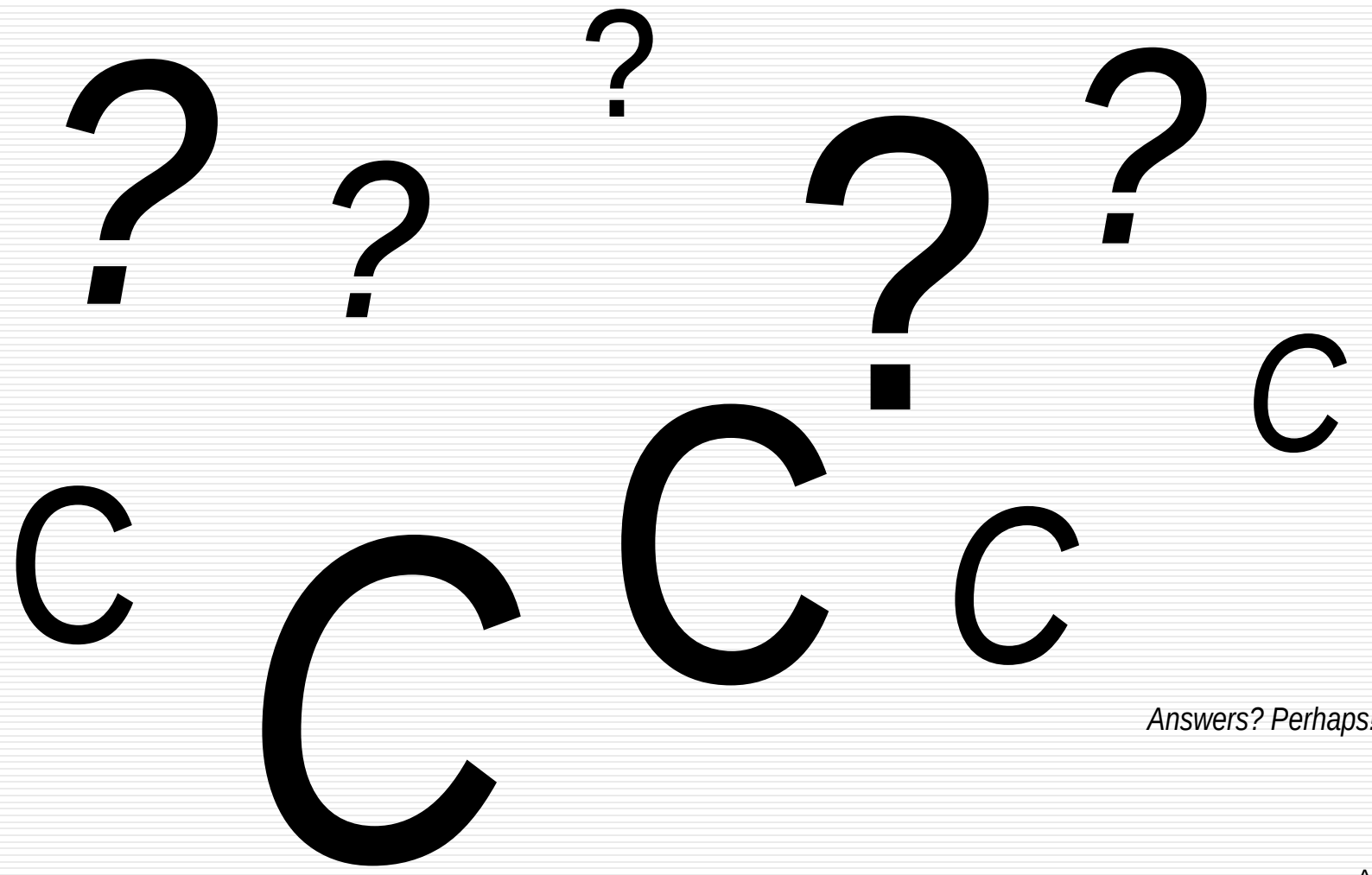
Questions/Comments



Answers? Perhaps!

References / Suggested Reading

- *IEEE Standard for Software Verification and Validation*; IEEE Standard 1012 2004; IEEE Computer Society
- *Capability Maturity Model Integration (CMMI®) for Development v1.3 2010*; Software Engineering Institute (SEI)
- *Reducing Risks with the Proper Specification of Software Requirements*; Al Florence; CrossTalk; April 2002
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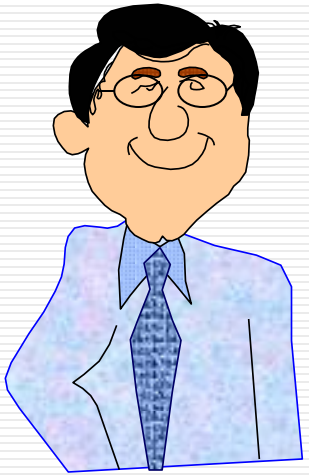
Contact Information



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